The HED Meteorite Clan: Visible-to-Near-Infrared Spectral Diversity at 81µm Spatial Resolution
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Mentors: Bethany Ehlmann and Abigail Fraeman

The HED meteorite clan are mafic and ultramafic igneous rocks and impact breccias, widely thought to originate from the asteroid 4 Vesta. Eucrites are surface basalts or shallow cumulate gabbros, while diogenites formed in plutons at greater depth. Howardites are a regolith breccia of mostly eucrite and diogenite, and possibly also exogenous material. In 2011 the Dawn spacecraft provided visible-to-near-infrared spectra of the Vestan surface with 70m per pixel resolution, however this resolution is insufficient to reliably extract all mineral components. Spectra indicate that carbon-rich impactors have deposited material on the surface, and it is unclear how much of the olivine in the regolith these are responsible for. In this study, a collection of HED meteorites are analysed using the Ultra-Compact Imaging Spectrometer (UCIS) at approximately 81µm per pixel resolution. Methods of hyperspectral characterisation are developed to reveal their spectral diversity at this small spatial scale and their mineralogy is interpreted. Using these methods, olivine grains can be rapidly distinguished from other minerals. Results from this study will inform interpretations of Vestan surface spectra, and provide evidence regarding the cooling history of Vesta and the identification of exogenous material, including olivine, and its interaction with native lithologies.

Rapid Estimation of Earthquake Magnitude and Epicenter using Ground Motion Parameters
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Earthquake early warning systems (EEWS) are designed to provide several seconds to tens of seconds of warning that shaking from an earthquake is imminent at the user location. Such systems use a network of seismometers scattered across an area with active faults to constantly monitor and report ground motion. When an earthquake begins, algorithms must rapidly analyze ground motion data and estimate the epicenter and magnitude of the event. If an accurate estimate can be made quickly enough, an alert can be issued, possibly giving individuals crucial seconds to find shelter. EEWS are dependent on algorithms that can quickly and accurately make magnitude and epicenter estimates. One of the algorithms used by ShakeAlert, an EEWS being developed for the West Coast of the United States, is the TauC-Pd On-Site algorithm. On-Site currently uses the ground motion parameter TauC to estimate the magnitude of an event using a single station. This paper proposes an alternative method for estimating the magnitude of an event at a single station that uses the attenuation of peak displacement and peak velocity with distance from the epicenter. Results suggest that this attenuation model produces more accurate magnitude predictions than those made by using TauC. Additionally, a new method for more accurately determining the epicenter of an event based on p-wave arrival times is also proposed. Analyses of test data show that the two methods provide improved performance and robustness of the OnSite algorithm.

Establishment and Analysis of Metabolic Relationships in Co-Cultures of Sulfur Oxidizing and Reducing Bacteria
Ana Gonzalez
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Sulfur-oxidizing bacteria (SOB) and sulfate-reducing bacteria (SRB) have been found closely associated in environments like microbial mats, hydrothermal vents and marine and freshwater sediment. It has been proposed that SOB and SRB participate in a closed syntrophic sulfur cycle, but evidence for such has not been found in the environment. An SOB and SRB co-culture has been established and bioorthogonal noncanonical amino acid tagging (BONCAT) coupled with fluorescent in-situ hybridization (FISH) will be performed on the culture. Using these methods I will be able to both taxonomically identify my cultures through FISH and visualize their metabolic relationships through BONCAT. A greater understanding of the spatial and metabolic interactions between SOB and SRB will allow researchers to more thoroughly tackle the question of the existence of a closed syntrophic sulfur cycle.

Oxygen Isotope Studies of Mineral Separates in Eucrite Meteorites
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The eucrites are basaltic meteorites belonging to the howardite, eucrite, and diogenite (HED) clan. The petrology and oxygen isotope compositions of the HEDs suggest that they derive from a common, differentiated parent body, likely asteroid 4 Vesta. Experimental work has demonstrated that eucrite compositions cluster around the 1-atmosphere olivine, pyroxene, plagioclase peritectic, leading to the hypothesis that eucrite meteorites represent low-degree partial melts from a differentiated source. However, 26Mg excesses in HEDs indicate that the young planetary body was hot, due to decay of the extinct radionuclide 26Al. Heating by 26Al-26Mg decay may necessitate high-degree, rather than low-degree, partial melting. There has been significant work documenting HED whole rock oxygen isotope compositions, however separate mineral phases have received less attention. Oxygen isotope partitioning between minerals is temperature dependent, enabling a detailed study of thermal histories and potential means to discriminate between
petrogenetic models for eucrite formation. Preliminary modelling results using parameterised partition
functions, mass balance, and available published data, suggest that oxygen isotope fractionations between
pyroxene and plagioclase reflect temperatures ranges of 500-1100°C. Additional high precision laser
fluorination analysis of mineral phases will illuminate the thermal history of eucrite meteorites. Data will be
collected pending resolution of equipment maintenance issues.

**Investigating the Thermal History of Australasian Tektites by Studying Lechatelierite Inclusions**

Richard Turley

*Mentors: Edward Stolper and Catherine Macris*

Tektites are impact glasses formed during complex processes of melting and chemical mixing in the vapour
plume produced by early crater excavation following the collision of a large, hypervelocity projectile with the
Earth's surface. Oblique collision of such a projectile causes geographical dispersal of tektites to form strewn
fields. This project examined tektites from various localities in the Australasian strewn field to study a
hypothesised relationship between their thermal history and spatial distribution. The focus was on investigation
of chemical diffusion between lechatelierite inclusions (pure SiO₂ glass generated by the shock melting of
quartz) and the tektite host glass (of approximately rhyolitic composition). Using an electron probe micro-
analyser (EPMA), major-element profiles were created of transects extending from the lechatelierite core into
the host matrix. Profiles show smooth curves with a rapid decrease in SiO₂ concentration at the
lechatelierite/host contact, indicative of diffusion between the lechatelierite and host glass. These profiles will
be compared to an existing experimental dataset of profiles from synthetic tektites, created at known
temperature/time conditions in an aerodynamic levitation laser furnace. This will allow estimation of the
thermal conditions of the tektite's formation and give unique insights into plume dynamics.